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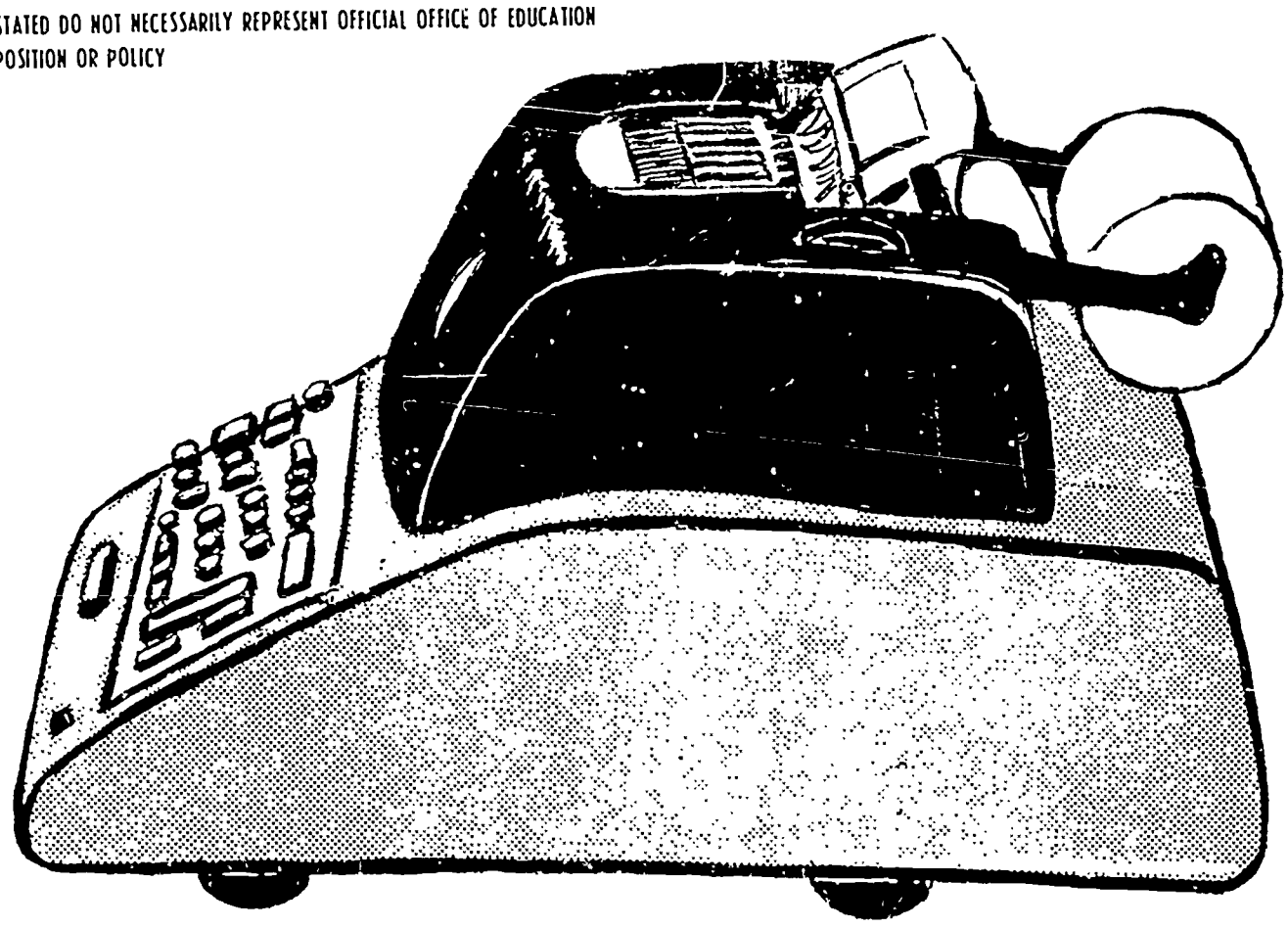
ABSTRACT

Reported is a study to determine the effects of calculators upon the achievement, attitude, and academic motivation of students in mathematics classes designed for low achievers at Miami Senior High School. An experimental and a control class were administered criterion instruments at the beginning and at the conclusion of the study. Analysis of covariance was used to insure comparability of the two classes, and results of the testing were treated statistically to determine whether significant differences existed. In addition, taped interviews were conducted at the midpoint of the study and videotaping was used to illustrate changes in student performance in the experimental and control classes. The following conclusions were offered - (1) the use of printing calculators by the experimental group produced no statistically significant gains in mathematical achievement, and (2) a more favorable attitude toward mathematics and a weaker degree of academic motivation were recorded by both groups at the conclusion of the study. (RP)

MIAMI SPRINGS SENIOR HIGH SCHOOL

RESEARCH REPORT

FUNCTIONS OF THE CALCULATOR IN THE MATHEMATICS LABORATORY



BOARD OF PUBLIC INSTRUCTION
DADE COUNTY, FLORIDA

MIAMI SPRINGS SENIOR HIGH SCHOOL

FUNCTIONS OF THE CALCULATOR IN THE MATHEMATICS LABORATORY FOR LOW ACHIEVERS

BY

JUNE ELLIS

AND

AL CORUM

A RESEARCH STUDY

CONDUCTED AT MIAMI SPRINGS SENIOR HIGH SCHOOL
A PARTICIPANT IN THE ESEA TITLE III
PROJECT OF /I/D/E/A/

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When the children have not learned, we have blamed the children; the ways and standards of the educational system were assumed to be immutable. But what would we think of a doctor who, when his treatment fails, blames the patient? When penicillin fails, he tries another drug, or an operation, or any one of the other weapons at his command. He assumes an obligation - that the patient will get well - and works till that is accomplished. The schools should be given the resources- and the obligation - to do the same, trying experiments and testing their results until the best approach is found.

Robert F. Kennedy

PART I

THE PROBLEM AND ITS BACKGROUND

The Need for the Study

We need only to consider the world of today to see the world of tomorrow, a world of technology founded on mathematics, in need of a mathematically literate manpower.

Since this manpower will include the semi-skilled, as well as the skilled and the professionals, our schools should provide an environment compatible with varying intellectual abilities, attitudes, motivation, and learning patterns.

During the past fifteen years, the greater part of curricular revision has been directed toward the college bound. Now, as educators recognize the need for effective programs for the non-college bound, numerous paradigms are being developed which utilize materials and teaching strategies appropriate for these students.

Unfortunately, there is a dearth of published research findings or other evaluative criteria pertaining to these endeavors. Consequently, no formal survey of related research will be presented in this report.

ENVIRONMENT OF THE STUDY

The Mathematics Laboratory is an environment of experiences especially designed for the high school student who has encountered a low achievement in mathematics due to his inability to understand and put to use the basic mathematical concepts, and/or chronic lack of success in the mathematics classroom.

It is designed, therefore, to motivate the student through assuring him of some initial mathematical successes. The student is afforded the opportunity for concrete experiences of a "let's talk about it, let's do it" nature. Teaching strategies are planned to guide him toward the development of meaningful generalizations and to further encourage him in a positive direction.

The written materials are prepared to allow the student to proceed at his own rate. The activities developed from industry and the physical sciences are used as a motivational base in skill instructions and in generating mathematical generalizations. Self-pacing and experiences of a concrete nature appealing to the student's maturation, education, and social frame of reference help to motivate a completion of successful learning and to dissolve the lock-step syndrome of the traditional classroom.

Student involvement encompasses active participation in discussions, activities, and self-evaluation. This also implies that students will assist teachers and other students, accept responsibility for self-discipline, and develop the ability to appropriately self-pace their learning experiences.

GENERAL TEACHER OBJECTIVES

The general objectives of teachers in the mathematics laboratory are to:

1. Accept the student as an individual and as a worthy member of the class.

2. Provide the classroom atmosphere conducive to student involvement and student-teacher interaction that will guide the student to the discovery of patterns, to the forming of generalizations, to abstracting of rules and principles, and to the application of these rules and principles in varied settings.

3. Guide the student in the formulation and acceptance of realistic goals, and to develop a means by which the student can be constantly aware of his progress toward these goals.

4. Assist the student in developing a more positive attitude toward his learning experiences in mathematics.

5. Incorporate other cultural and educational elements of the school and community into a unified learning program.

6. Capitalize on the use of semi-programmed material as a vehicle for the reinforcement of reading, a necessary skill in communication.

7. Involve the student in his learning of mathematics through small group and large group activities which include the active participation of hands and minds. This participation includes the use of manipulative materials such as games and puzzles geared to helping students seek patterns, and the use of machinery such as adding machines, calculators, and cash registers.

8. Provide an evaluation system to measure the effectiveness of the mathematics laboratory in student involvement, mathematical achievement, and attitudinal development of the student with respect to himself and toward the learning and use of mathematics.

The role of the teacher or teaching team is to manage individual learners in a supportive rather than a telling situation. Student marking is based upon the "Satisfactory - Unsatisfactory" scale, rather than the more conventional "A - D" scale, Therefore, no attempt was made in this study to measure changes in academic marks.

THE PURPOSE OF THE STUDY

The purpose of this study was to determine the effects of calculators upon the achievement, attitude, and academic motivation of students in mathematics classes designed for low-achievers at Miami Springs Senior High School.

The following questions were investigated in this study:

1. Will students using calculators in a mathematics class for the non-college bound attain a higher level of mathematical achievement than students in a comparable class not using calculators?

2. Will these same students using calculators indicate a more favorable attitude toward mathematics than students in a comparable class not using calculators?

3. Will these students using calculators indicate a stronger degree of academic motivation than students in a comparable class not using calculators?

Delimitations. This study was delimited to two classes of students (approximately 45) in the Mathematics Laboratory Program at Miami Springs Senior High School. Teachers and guidance counselors recommended these students on the basis of their previous achievement in mathematics classes.

Limitations. The study was affected by the following limitations:

1. Insufficient ability criteria, such as SCAT scores, were available for use as a valid measure.

2. Technical difficulties prevented video and audio tapings of classroom activities on a pre and post basis, and forced a change to single tapings at the midpoint of the study.

Definition of Terms

Listed below are selected terms that were used in this study:

1. Calculator - An electric machine with features that include high speed, memory and automatic constant, printed record, and the capability of performing combined operations.

2. Experimental Class - A mathematics class for low-achieving students in which calculators were used as an integral part of the learning environment.

3. Control Class - A mathematics class, similar to the experimental class, in which no calculators were used.

4. CALIFORNIA ARITHMETIC TEST (JUNIOR HIGH LEVEL FORM W)- A standardized test used to measure student mathematical achievement.

5. LEE-CLARK ARITHMETIC FUNDAMENTALS SURVEY-TEST FORM A - A standardized achievement test covering twenty different basic processes of arithmetic, with two problems in each process. This test was used as a guide for correct phase placement of students at the beginning of the school year.

6. ATTITUDE TOWARD MATHEMATICS - An attitude scale used to assess student attitude toward mathematics.

7. THE ABERDEEN ACADEMIC MOTIVATION INVENTORY - A self-rating inventory used to measure motivation in students.

PART II

THE DESIGN AND PROCEDURES OF THE STUDY

The Experimental and Control Classes

In the initial phase of the study, an experimental and a control class were identified. To promote randomness, the two classes were accepted as established through the open, college-type student registration procedure conducted at Miami Springs Senior High School.

In an attempt to control for the teacher variable, both classes were taught by the same team of two teachers, assisted by one teacher aide and one student assistant.

Evaluative Criteria

Criterion instruments were administered twice - at the beginning and at the conclusion of the study. A descriptive profile for each student involved in the study was constructed to illustrate his relative position as determined by the criterion instruments. The analysis of covariance was used to insure comparability of the two classes, and results of the testing were treated statistically to determine whether significant differences existed.

In addition to the written criterion measures described in Part I, structured interviews were taped with randomly selected students from each class. Responses to these interviews were quantified on a five-point ascending scale (1-5). Opposite poles of the scale were considered to represent highly negative and highly positive student attitudes toward mathematics.

The taped interviews were conducted at the midpoint of the study by guidance personnel at Miami Springs Senior High School. Ratings were attached to each interview by a panel of three teachers, who were not involved in the study. The mean of the three ratings was used as the official measure of attitude obtained from student interviews.

A final method of evaluation involved the use of video taping to illustrate changes in student performance in the experimental and control classes. A series of laboratory activities were taped at the midpoint of the study, and were evaluated by a four-teacher panel, consisting of two teachers of mathematics and two teachers from other subject areas. Members of the panel viewed the tape individually and reacted to them on qualitative and quantitative bases.

The qualitative emphasis of the rating scales was upon the over-all atmosphere which existed in the laboratory, and the quantitative aspect dealt with the extent of which certain specific characteristics existed in the laboratory. These characteristics included student self-directedness, individualized materials and instruction, and the use of the problem-solving method by students and teachers. Again, a five-point rating scale was used for the quantitative evaluation, and mean teacher ratings were used.

PART III

FINDINGS OF THE STUDY

The findings of the study relate to the research design and deal with the following major areas: (1) results of objective measures and (2) results of subjective measures.

Results of Objective Measures. Two objective measures of mathematical ability were used in the study. The first of these, the CALIFORNIA ARITHMETIC TEST, attempted to measure each student's reasoning ability and computational skills.

Mean scores obtained by the experimental group on the CALIFORNIA ARTIHMETIC TEST were as follows:

	Raw Score	Grade Placement
Pre-Test		
Reasoning	20.0	6.7
Fundamentals	31.1	6.3
Total	25.6	6.5
Post-Test		
Reasoning	23.1	7.2
Fundamentals	33.8	6.6
Total	28.5	6.9

See Tables I and II for a complete tabulation of scores obtained by the experimental group on this test.

TABLE I

SCORES OBTAINED BY THE EXPERIMENTAL GROUP OF THE PRE-TEST OF THE CALIFORNIA ARITHMETIC TEST

STUDENT NUMBER	REASONING RAW SCORE	REASONING GRADE PLACEMENT	FUNDAMENTALS RAW SCORE	FUNDAMENTALS GRADE PLACEMENT	GRADE PLACEMENT TOTAL
1	26	7.9	30	6.2	5.4
2	20	6.8	48	7.7	7.5
3	29	8.3	31	6.3	6.2
4	24	7.6	35	6.7	7.5
5	8	4.3	17	4.9	6.4
6	8	4.3	13	4.7	6.9
7	20	6.8	32	6.4	5.2
8	22	7.2	28	6.0	7.1
9	22	7.2	39	7.1	7.3
10	23	7.4	42	7.3	7.3
11	22	7.2	29	6.1	7.2
12	10	4.5	31	6.3	4.6
13	27	8.0	37	6.7	4.5
14	20	6.8	23	5.5	6.6
15	24	7.6	43	7.4	6.6
16	20	6.8	28	6.0	7.2
17	21	7.0	36	6.8	7.4
18	14	5.4	18	4.9	6.7
TOTALS	360	121.1	560	113.0	117.6
MEANS	20	6.7	31.1	6.3	6.5

TABLE II

SCORES OBTAINED BY THE EXPERIMENTAL GROUP ON THE POST-TEST OF THE CALIFORNIA ARITHMETIC TEST

STUDENT NUMBER	REASONING RAW SCORE	REASONING GRADE PLACEMENT	FUNDAMENTALS RAW SCORE	FUNDAMENTALS GRADE PLACEMENT	TOTAL GRADE PLACEMENT
1	21	4.7	32	6.3	6.7
2	30	7.9	54	8.4	8.5
3	34	8.6	39	7.1	8.0
4	23	7.9	21	5.2	6.3
5	13	5.7	20	5.3	5.3
6	14	8.6	18	5.1	5.3
7	20	5.9	38	7.1	7.0
8	18	7.0	23	5.6	6.2
9	22	8.5	37	6.9	7.0
10	33	8.9	43	7.4	8.1
11	31	7.3	40	7.2	7.9
12	11	5.3	17	4.9	4.8
13	26	5.5	38	7.0	7.5
14	31	6.8	38	7.1	7.9
15	27	6.6	37	6.9	7.4
16	15	7.1	35	6.7	6.2
17	31	8.8	39	7.1	7.9
18	16	8.6	39	7.2	6.6
TOTALS	416	129.7	608	118.5	124.6
MEANS	23.1	7.2	33.8	6.6	6.9

The control group obtained the following mean scores on the CALIFORNIA ARITHMETIC TEST:

	Raw Score	Grade Placement
Pre-Test		
Reasoning	24.3	7.6
Fundamentals	35.8	6.8
Total	30.6	7.2
Post-Test		
Reasoning	26.8	7.9
Fundamentals	40.5	7.4
Total	33.7	7.7

For a complete presentation of scores obtained by the control group on this test, see Tables III and IV.

The second objective test of mathematical ability used in the study was the LEE-CLARK ARITHMETIC FUNDAMENTALS SURVEY-TEST. Pre-and post-tests yielded the following mean scores:

	Raw Score	Percentage of Correct Answers
Experimental Group		
Pre-Test	12.2	32
Post-Test	13.0	37
Control Group		
Pre-Test	16.7	44
Post-Test	19.0	51

See Tables V and VI for complete results obtained with the LEE-CLARK test.

TABLE III

SCORES OBTAINED BY THE CONTROL GROUP
ON THE PRE-TEST OF THE CALIFORNIA
ARITHMETIC TEST

STUDENT NUMBER	REASONING RAW SCORE	REASONING GRADE PLACEMENT	FUNDAMENTALS RAW SCORE	FUNDAMENTALS GRADE PLACEMENT	TOTAL GRADE PLACEMENT
1	26	7.9	64	10.1	9.0
2	23	7.4	25	5.7	6.6
3	24	7.6	39	7.1	7.4
4	23	7.4	39	7.1	7.3
5	18	6.5	37	6.9	6.7
6	27	8.0	61	9.5	8.8
7	29	8.3	26	5.8	7.1
8	28	8.2	27	5.9	7.1
9	26	7.9	45	7.5	7.7
10	18	6.4	25	5.7	6.1
11	21	7.0	22	5.4	6.2
12	30	8.5	31	6.3	7.4
13	36	9.1	39	7.1	8.1
14	26	7.9	41	7.3	7.6
15	25	7.7	38	7.0	7.4
16	18	6.6	24	5.6	6.2
17	25	7.7	40	7.2	7.5
18	18	6.4	31	6.3	6.4
19	23	7.4	34	6.6	7.0
20	24	7.6	31	6.3	7.0
21	22	7.2	33	6.5	6.9
TOTALS	510	158.7	752	142.9	151.5
MEANS	24.3	7.6	35.8	6.8	7.2

TABLE IV

SCORES OBTAINED BY THE CONTROL GROUP ON THE POST-TEST OF THE CALIFORNIA ARITHMETIC TEST

STUDENT NUMBER	REASONING RAW SCORE	REASONING GRADE PLACEMENT	FUNDAMENTALS RAW SCORE	FUNDAMENTALS GRADE PLACEMENT	TOTAL GRADE PLACEMENT
1	32	8.7	63	9.8	9.3
2	29	8.5	47	7.9	8.2
3	19	6.7	31	6.4	6.6
4	24	7.6	36	6.8	7.2
5	18	6.5	44	7.5	7.5
6	38	8.9	64	10.0	9.5
7	36	9.2	51	8.0	8.6
8	28	8.3	36	6.9	7.6
9	15	5.7	38	7.0	6.4
10	15	5.7	38	7.0	6.4
11	29	8.4	32	8.4	8.4
12	32	8.7	40	7.3	8.0
13	34	9.0	45	7.5	8.3
14	33	8.9	38	7.1	8.0
15	25	7.7	22	5.4	6.6
16	18	6.6	28	6.1	6.4
17	29	8.4	50	7.8	8.1
18	17	6.2	30	6.2	6.2
19	29	8.4	34	6.7	7.6
20	27	8.0	37	6.9	7.5
21	22	7.2	40	7.3	7.3
TOTALS	563	166.0	850	154.5	161.3
MEANS	26.8	7.9	40.5	7.4	7.7

TABLE V

SCORES OBTAINED BY THE EXPERIMENTAL GROUP ON THE PRE-AND POST-TEST OF THE LEE-CLARK ARITHMETIC FUNDAMENTALS TEST

STUDENT NUMBER	PRE-TEST RAW SCORE	PERCENTAGE OF CORRECT ANSWERS	POST-TEST RAW SCORE	PERCENTAGE OF CORRECT ANSWERS
1	10	26	13	34
2	17	45	21	55
3	11	29	15	39
4	19	50	14	37
5	05	14	7	19
6	04	11	7	19
7	11	29	11	29
8	07	19	6	16
9	11	29	14	37
10	17	45	14	37
11	13	34	18	47
12	04	11	9	24
13	11	29	10	26
14	14	37	8	74
15	15	39	19	50
16	20	53	15	39
17	20	53	23	61
18	11	29	11	29
TOTALS	220	582	235	672
MEANS	12.2	32	13.0	37

TABLE VI

SCORES OBTAINED BY THE CONTROL GROUP ON THE PRE-AND-POST-TESTS OF THE LEE-CLARK ARITHMETIC FUNDAMENTALS TEST

STUDENT NUMBER	PRE-TEST RAW SCORE	PERCENTAGES OF CORRECT ANSWERS	POST-TEST RAW SCORE	PERCENTAGES OF CORRECT ANSWERS
1	21	55	19	50
2	15	39	15	39
3	18	47	21	55
4	11	29	22	58
5	15	39	21	55
6	32	84	33	87
7	19	50	20	53
8	12	32	14	37
9	23	61	24	63
10	13	34	17	45
11	12	32	13	34
12	20	52	16	42
13	21	55	24	63
14	25	56	22	58
15	15	39	15	39
16	05	13	09	24
17	20	53	31	82
18	07	19	07	19
19	10	26	17	45
20	16	42	22	58
21	21	55	23	61
TOTALS	351	922	405	1067
MEANS	16.7	44	19.0	51

Results of Subjective Measures. In an attempt to measure student attitude toward mathematics, the ATTITUDE TOWARD MATHEMATICS SCALE was administered at the beginning and at the end of the study. In a similar manner, the ABERDEEN ACADEMIC MOTIVATION INVENTORY was used to assess student attitude toward school, generally.

Responses on the attitude scale were weighted ($\pm$ 5 through $\pm$ 1). For example, a response of "strongly agree" to a positively keyed question had a weight of + 5 ; a response of "strongly disagree" to the same question was weighted + 1. On negatively keyed responses, "strongly agree" was weighted - 5; "strongly disagree" to the same question was weighted - 1.

The weighted responses from the attitude scale, computed to obtain a weighted score ($\pm$ 1.00 through - 1.00), indicated whether a student's attitude toward mathematics was positive or negative. For example, a score of + .80 indicated that the student had a high positive attitude toward mathematics.

Mean scores obtained on the ATTITUDE TOWARD MATHEMATICS SCALE were as follows:

	First Administration	Second Administration	Difference
Experimental Group	- .11	- .10	+ .01
Control Group	+ .09	+ .11	+ .02

See Tables VII and VIII for details of the results summarized above.

TABLE VII

RESULTS OBTAINED ON THE ATTITUDE TOWARD MATHEMATICS SCALE BY STUDENTS IN THE EXPERIMENTAL GROUP OF THE MATHEMATICS LABORATORY

STUDENT NUMBER	SCORE ON FIRST ADMINISTRATION	SCORE ON SECOND ADMINISTRATION	DIFFERENCE BETWEEN SCORES
1	- .35	- .23	+ .12
2	+ .18	+ .03	- .15
3	+ .60	+ .20	- .40
4	-1.00	- .65	+ .35
5	- .60	- .68	- .08
6	+ .05	+ .08	+ .03
7	- .28	- .20	+ .08
8	+ .10	- .05	- .15
9	- .25	- .20	+ .05
10	- .35	- .45	- .10
11	+ .10	0	- .10
12	- .13	+ .33	+ .46
13	+ .65	+ .48	- .17
14	- .65	- .35	+ .30
15	- .55	- .25	+ .30
16	- .10	- .18	- .08
17	+ .52	+ .03	- .49
18	+ .13	+ .28	+ .15
TOTALS	-1.93	-1.81	+ .12
MEANS	- .11	- .10	+ .007

TABLE VIII

RESULTS OBTAINED ON THE ATTITUDE TOWARD MATHEMATICS SCALE BY STUDENTS IN THE CONTROL GROUP OF THE MATHEMATICS LABORATORY

STUDENT NUMBER	SCORES ON FIRST ADMINISTRATION	SCORES ON SECOND ADMINISTRATION	DIFFERENCE BETWEEN SCORES
1	- .48	- .08	+ .40
2	+ .30	- .10	- .40
3	+ .03	+ .28	+ .25
4	- .20	- .33	- .13
5	- .43	- .50	- .07
6	+ .15	+ .28	+ .13
7	- .05	- .15	- .10
8	+ .13	- .15	- .28
9	- .13	+ .18	+ .31
10	+ .08	- .03	- .11
11	+ .07	+1.00	+ .93
12	+ .50	- .15	- .65
13	+ .20	+ .33	+ .13
14	- .05	- .13	- .08
15	+ .10	+ .25	+ .15
16	- .25	+ .08	+ .33
17	+ .33	- .08	- .41
18	+ .33	+ .58	+ .25
19	+ .23	+ .28	+ .05
20	+ .43	+ .30	- .13
21	+ .50	+ .48	- .02
TOTALS	+1.79	+2.34	+ .55
MEANS	+ .09	+ .11	+ .026

The ABERDEEN ACADEMIC MOTIVATION INVENTORY, which was used to assess student attitude toward school, was scored by counting the number of positive responses. A large number of such responses indicated a strong positive attitude toward school.

Mean scores on the ABERDEEN INVENTORY were as follows:

	First Administration	Second Administration	Difference
Experimental Group	+ 16.0	+ 14.0	-2.0
Control Group	+ 17.0	+ 13.0	-4.0

A complete listing of the results obtained with the INVENTORY is contained in Tables IX and X.

Synthesis of the Objective Findings

Analysis of Covariance. A one-way analysis of covariance indicated the following statistical differences between the experimental and control groups on tests of mathematical achievement:

1. LEE-CLARK ARITHMETIC TEST

   There was a significant difference at the .03 level of confidence in support of the control group.

2. CALIFORNIA ARITHMETIC TEST

   a. Fundamentals (Grade Placement)- There was an important (although not statistically significant) difference at the .10 level of confidence in support of the control group.

   b. Reasoning and Total (Raw Score and Grade Placement)- No important differences were indicated between the experimental and control groups.

See Table XI for complete results of the analysis of covariance.

TABLE IX

RESULTS OBTAINED ON THE ABERDEEN MOTIVATION INVENTORY BY STUDENTS IN THE EXFERIMENTAL GROUP OF THE MATHEMATICS LABORATORY

STUDENT NUMBER	SCORE ON FIRST ADMINISTRATION	SCORE ON SECOND ADMINISTRATION	DIFFERENCE BETWEEN SCORES
1	18	13	- .05
2	18	11	- .07
3	16	19	+ .03
4	6	10	+ .04
5	15	13	- .02
6	18	14	- .04
7	17	15	- .02
8	20	14	- .06
9	10	16	+ .06
10	11	11	00
11	19	17	- .02
12	15	17	+ .02
13	18	14	- .04
14	16	11	- .05
15	21	14	- .07
16	15	15	00
17	6	13	+ .07
18	22	13	- .09
TOTALS	281	250	- .31
MEANS	16.0	14.0	-1.72

TABLE X

RESULTS OBTAINED ON THE ABERDEEN MOTIVATION INVENTORY BY STUDENTS IN THE CONTROL GROUP OF THE MATHEMATICS LABORATORY

STUDENT NUMBER	SCORE ON FIRST ADMINISTRATION	SCORE ON SECOND ADMINISTRATION	DIFFERENCE BETWEEN SCORES
1	14	13	- .01
2	13	13	0
3	17	10	- .07
4	11	13	+ .02
5	08	17	+ .09
6	17	15	- .02
7	21	14	- .07
8	16	15	- .01
9	18	16	- .02
10	18	8	- .10
11	20	11	- .07
12	13	16	+ .03
13	18	11	- .07
14	20	12	- .08
15	18	12	- .06
16	20	10	- .10
17	15	12	- .03
18	22	13	- .09
19	15	11	- .04
20	15	13	- .02
21	18	14	- .04
TOTALS	347	269	- .76
MEANS	17.0	13.0	-3.62

TABLE XI

RESULTS OF A ONE-WAY ANALYSIS OF COVARIANCE
FOR THE LEE-CLARK AND CALIFORNIA
ARITHMETIC TESTS

TEST	F	SIGNIFICANCE
LEE-CLARK	4.96	P < .05
CALIFORNIA ARITHMETIC		
REASONING RAW SCORE	0.09	P > .05
REASONING GRADE PLACEMENT	0.12	P > .05
FUNDAMENTALS RAW SCORE	1.96	P > .05
FUNDAMENTALS GRADE PLACEMENT	2.79	P > .05
TOTAL GRADE PLACEMENT	0.74	P > .05

Chi-Square Test of Significance. A further attempt to determine significant differences in the study was accomplished through the use of Chi-square with Fisher's exact test. Results obtained with this statistical procedure were as follows:

1. LEE-CLARK ARITHMETIC TEST

   There was a significant difference at the .05 level of confidence in support of the control group.

2. CALIFORNIA ARITHMETIC TEST

   a. Fundamentals (Grade Placement) - On the pre-test, there was a significant difference at the .05 level of confidence in support of the control group.

   b. Fundamentals (Raw Score) - On the post-test, there was a significant difference at the .05 level of confidence in support of the control group.

   c. Reasoning and Total (Raw Score and Grade Placement) - No important differences were indicated between the experimental and control groups.

(See Tables XII for Chi-Square results.)

A most interesting observation resulted from an analysis of the scores obtained by both groups on the CALIFORNIA ARITHMETIC TEST. It was observed that grade placement scores on the pre-test indicated that both groups were more than three years below grade level in mathematical achievement. Nevertheless, grade placement scores on the post-test showed that both groups had progressed at a fairly "average" rate. That is, there was an

TABLE XII

RESULTS OF A CHI-SQUARE TEST OF SIGNIFICANCE
FOR THE LEE-CLARK AND CALIFORNIA
ARITHMETIC TESTS

TEST	CHI-SQUARE	DEGREES OF FREEDOM	SIGNIFICANCE
LEE-CLARK			
PRE-TEST	5.9621	5	$P > .05$
POST-TEST	10.0477	4	$P < .05$
CALIFORNIA ARITHMETIC			
REASONING RAW SCORE			
PRE-TEST	5.2963	3	$P > .05$
POST-TEST	1.2006	2	$P > .05$
REASONING GRADE PLACEMENT			
PRE-TEST	6.2730	5	$P > .05$
POST-TEST	7.2494	5	$P > .05$
FUNDAMENTALS RAW SCORE			
PRE-TEST	5.9844	4	$P > .05$
POST-TEST	11.1816	5	$P < .05$
FUNDAMENTALS GRADE PLACEMENT			
PRE-TEST	10.2193	4	$P < .05$
POST-TEST	6.2730	6	$P > .05$
TOTAL GRADE PLACEMENT			
PRE-TEST	7.3634	5	$P > .05$
POST-TEST	7.1613	5	$P > .05$

increase of approximately one month on the total grade placement scale for each calendar month of the study.

In this study, as in most research studies, it was not possible to identify all of the contributing influences. However, it appeared from the research findings that the general learning environment permeating the Mathematics Laboratory was more important to student achievement than were the calculators or any other known single factor.

Synthesis of Subjective Findings

Although the subjective findings were not treated with statistical rigor, they did provide evidence important to the study.

Attitude Toward Mathematics. The results of the ATTITUDE TOWARD MATHEMATICS SCALE indicated a trend in the positive direction in both the experimental and control groups. The experimental group showed a mean gain of .01 between the first and second administration of the scale while the control group experienced a mean gain of .02. (A copy of the ATTITUDE SCALE is included in Appendix A.)

After a study of the objective findings, the researchers generalized that the Laboratory environment was the most critical factor in student achievement. A study of the subjective findings extended that generalization. That is, the Laboratory environment was also considered to be most influential upon student attitude toward mathematics.

Academic Motivation. A trend in the negative direction for both groups was evidenced on the ABERDEEN ACADEMIC MOTIVATION INVENTORY. Scores on the two administrations of this instrument registered a mean loss of 2.0 for the experimental group and 4.0 for the control group.

It was difficult to gauge the effects of this environment upon academic motivation, since the MOTIVATION INVENTORY included a large number of factors not directly related to the Mathematics Laboratory. (A copy of the INVENTORY is included in Appendix A.)

Classroom Environment. A further attempt to understand the effects of the Laboratory environment was accomplished through the utilization of audio and video tapes. These tapes, containing student interviews and scenes of classroom activity, were evaluated by panels of teachers according to the procedures outlined in PART II of this report. (See Appendix B for copies of the evaluation forms used by panel members.)

The evaluators viewed and listened to the tapes individually. Their ratings were then quantified on a five-point ascending scale (1-5) and mean ratings were computed for the experimental and control classes. Although the evaluation forms for the audio and video tapes were different, both ratings were processed in a similar fashion.

According to the ratings, a more stimulating learning environment existed in the experimental class. This impression was voiced by the evaluators after they had responded to the audio and video tapes. (See Table XIII for a complete presentation of the ratings attached to the tapes by panel members.)

TABLE XIII

TEACHER RATINGS ASSIGNED TO AUDIO AND VIDEO TAPES CONCERNING THE MATHEMATICS LABORATORY

	EVALUATOR	MEAN RATING	
VIDEO TAPES		EXPERIMENTAL	CONTROL
	A	4.6	4.2
	B	4.6	4.4
	C	5.0	5.0
	D	4.6	4.2
	MEAN OF SCORES	4.70	4.45
AUDIO TAPES			
	A	4.2	3.6
	B	4.6	3.0
	C	4.4	3.6
	MEAN OF SCORES	4.40	3.40

PART IV

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Based upon the research findings, the following conclusions seem appropriate:

1. The use of printing calculators by the experimental group produced no statistically significant gains in the areas of mathematical achievement being studied. However, the control group did realize a significant gain in several of these areas.

2. A more favorable attitude toward mathematics, as measured by the ATTITUDE SCALE, was recorded by the experimental and control groups at the conclusion of the study.

3. A weaker degree of academic motivation was reported by both groups at the conclusion of the study. This loss in motivation probably resulted from negative influences outside of the Mathematics Laboratory environment. These influences included negativism toward school on the part of parents and peers, as evidenced by informal student comments as well as their responses on the MOTIVATION INVENTORY.

RECOMMENDATIONS

The following recommendations are based upon the findings, conclusions, and observations resulting from this study:

1. The calculator, or similar equipment, should be utilized in mathematics classes for low achievers. It was observed that these students benefited from the calculator as an instructional, social, and motivational device.

2. A unit of systematic instruction on the use of the calculator should be integrated into the total Laboratory program. (In this study, the calculator was used basically to check computational accuracy.)

3. The instructional materials in the Laboratory should be available in small, individualized units.

4. The Laboratory students should be given opportunities to employ their skill with the calculator in areas such as school enrollment, attendance, inventory, and student activities.

SUGGESTIONS FOR FURTHER RESEARCH

In the interest of furthering research related to the low achiever in mathematics, the following suggestions are offered:

1. A follow-up study should be conducted to determine the progress in achievement, attitude, and academic motivation of those Laboratory students who enroll in additional mathematics courses.

2. A study is needed to determine the multiple progress of students in a mathematics laboratory environment as compared with that of students in a traditional, group-paced class.

3. A concerted effort should be made to identify and cultivate multiple talents in low-achieving students. Such an effort should capitalize upon the talent measures being developed by Calvin Taylor and others.

4. A series of case studies involving Laboratory students should be conducted in order to help educators identify the learning styles of low-achievers.

APPENDICES

APPENDIX A

COPIES OF THE ATTITUDE TOWARD MATHEMATICS SCALE AND THE ABERDEEN ACADEMIC MOTIVATION INVENTORY

ATTITUDE TOWARD MATHEMATICS SCALE

The following is a list of statements which express the feeling a person has toward mathematics. Please indicate the extent of your agreement or disagreement with each statement as it concerns you.

	Strongly Agree	Agree	Un-Decided	Dis-Agree	Strongly Disagree
1. I am under a terrible strain in a math class.	A ( )	B ( )	C ( )	D ( )	E ( )
2. I do not like mathematics, and it scares me to have to take it.	F ( )	G ( )	H ( )	J ( )	K ( )
3. Mathematics is very interesting to me, and I enjoy math courses.	A ( )	B ( )	C ( )	D ( )	E ( )
4. Mathematics holds my attention and is fun to do.	F ( )	G ( )	H ( )	J ( )	K ( )
5. I think I can do mathematics and at the same time it is exciting.	A ( )	B ( )	C ( )	D ( )	E ( )
6. My mind goes blank and I am unable to think clearly when working math.	F ( )	G ( )	H ( )	J ( )	K ( )
7. I feel unsure when doing mathematics.	A ( )	B ( )	C ( )	D ( )	E ( )
8. Mathematics makes me feel mad.	F ( )	G ( )	H ( )	J ( )	K ( )
9. The feeling that I have toward mathematics is a good feeling	A ( )	B ( )	C ( )	D ( )	E ( )

ATTITUDE TOWARD MATHEMATICS SCALE (cont'd)

	Strongly Agree	Agree	Un-Decided	Dis-Agree	Strongly Disagree
10. Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.	F ( )	G ( )	H ( )	J ( )	K ( )
11. Mathematics is something which I enjoy a great deal.	A ( )	B ( )	C ( )	D ( )	E ( )
12. When I hear the word math, I have a feeling of dislike.	F ( )	G ( )	H ( )	J ( )	K ( )
13. I approach math with a feeling that I may not be able to do it.	A ( )	B ( )	C ( )	D ( )	E ( )
14. I really like mathematics.	F ( )	G ( )	H ( )	J ( )	K ( )
15. I have always enjoyed studying math.	A ( )	B ( )	C ( )	D ( )	E ( )
16. It makes me nervous to even think about having to do a math problem.	F ( )	G ( )	H ( )	J ( )	K ( )
17. I have never liked math, and it is my worst subject.	A ( )	B ( )	C ( )	D ( )	E ( )
18. I am happier in a class than in any other class.	F ( )	G ( )	H ( )	J ( )	K ( )
19. I feel at ease in mathematics and I like it very much.	A ( )	B ( )	C ( )	D ( )	E ( )
20. I feel that I like to do mathematics, it's enjoyable.	F ( )	G ( )	H ( )	J ( )	K ( )

ABERDEEN ACADEMIC MOTIVATION INVENTORY

Here are some questions about school and school work. In all the questions you must answer either "yes" or "no." Put a circle around the answer you wish to give. Answer ALL the questions TRUTHFULLY but quickly .

		RESPONSE	
1.	Do you like being asked questions in class?	Yes	No
2.	Does your mind often wander off the subject during lessons?	Yes	No
3.	Do you enjoy most lessons?	Yes	No
4.	Do your parents want you to start work when you are 16?	Yes	No
5.	Do you think school is rather a waste of time?	Yes	No
6.	Do you like to leave your homework till the last minute?	Yes	No
7.	If you were given lower marks than usual in a test, would this make you unhappy?	Yes	No
8.	Do you expect school to provide you with good qualifications for a job?	Yes	No
9.	Is it important to you to do well at school?	Yes	No
10.	Are you happier working with your hands?	Yes	No
11.	When you are given a difficult problem, do you enjoy trying to find the answer?	Yes	No
12.	Do your parents expect you to go to a university or college?	Yes	No

ABERDEEN ACADEMIC MOTIVATION INVENTORY (cont'd)

		RESPONSE	
13.	Do you generally find lessons rather dull?	Yes	No
14.	Do you dread being given a test on your homework?	Yes	No
15.	Do your friends think that you never take work seriously?	Yes	No
16.	Would you like to leave school as soon as possible?	Yes	No
17.	Do your parents tell you to enjoy yourself and not to worry about school?	Yes	No
18.	Do you work hard most of the time?	Yes	No
19.	Do your parents think that you must do well at school if you are to succeed in later life?	Yes	No
20.	Do your teachers think that you misbehave too much?	Yes	No
21.	Do you worry about not doing well in class?	Yes	No
22.	Are you more interested in games than school work?	Yes	No
23.	Do you find it difficult to keep your mind on your work?	Yes	No
24.	Do you always try your hardest to get your homework right?	Yes	No

APPENDIX B

EVALUATION FORMS USED FOR VIDEO AND AUDIO TAPES

MATHEMATICS LABORATORY EVALUATION FORM

Dear Teacher:

Listed below are some questions pertaining to the learning atmosphere in the Mathematics Laboratory, as shown in video-tape recordings. Would you please circle the number on the five-point rating scale which best describes your response to the taped classroom scenes. If you have additional comments, please write them in the space provided after each question and on the reverse side of this page.

1. The degree of spontaneous cooperation among students (seeking and giving assistance, attitude toward game playing and the use of classroom equipment, etc.) was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

2. The degree of spontaneous cooperation between students and teachers was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

3. The degree of ease with which students used classroom equipment was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

4. The variety of classroom learning materials was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

5. The degree of student self-direction (checking work, using materials and equipment, etc.) was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

MATHEMATICS LABORATORY EVALUATION FORM

Dear Teacher:

Listed below are some questions pertaining to the learning atmosphere in the Mathematics Laboratory. Would you please circle the number on the rating scale which in your opinion, shows the student's attitude toward each major area covered by the questions. If you have additional comments, please write them in the space provided after each question and on the reverse side of this paper.

1. The student indicated that his satisfaction with "hands-on" learning materials (puzzles, games, etc.) was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

2. The student indicated that his satisfaction with written learning materials was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

3. The student indicated that his satisfaction with classroom equipment (cash register, calculators, etc.) was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

4. The student indicated that his satisfaction with methods of teaching and classroom evaluation was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

5. The student indicated that his satisfaction with the responsibility of working independently and checking his own work was:

   (a) Excellent (b) Good (c) Fair (d) Poor (e) Very Poor

   Comments:_____

   _____

The lights begin to twinkle from the rocks:
The long day wanes: the slow moon climbs: the deep
Moans round with many voices. Come, my friends,
'Tis not too late to seek a newer world.

Alfred, Lord Tennyson